

great number of diverse parts or *organs*, which in turn are built up of a limited number of materials; the same material often entering into the composition of many different organs. These primary building materials are known as the *tissues*, and that branch of anatomy which deals with the characters of the tissues and their arrangement in various organs is known as *Histology*; or, since it is mainly carried on with the aid of the microscope, as *Microscopic Anatomy*. If, with the poet, we compare the Body to a house, we may go on to liken the tissues to the bricks, stone, mortar, wood, iron, glass and so on, used in building; and then walls and floors, stairs and windows, formed by the combination of these, would answer to anatomical organs.

Zoölogical Position of Man. External examination of the Human Body shows also that it presents certain resemblances to the bodies of many other animals: head and neck, trunk and limbs, and various minor parts entering into them, are not at all peculiar to it. Closer study and the investigation of internal structure demonstrates further that these resemblances are in many cases not superficial only, but that our Bodies may be regarded as built upon a plan common to them and the bodies of many other creatures: and it soon becomes further apparent that this resemblance is greater between the Human Body and the bodies of ordinary four-footed beasts, than between it and the bodies of birds, reptiles or fishes. Hence, from a zoölogical point of view, man's Body marks him out as belonging to the group of *Mammalia* (see *Zoölogy*), which includes all animals in which the female suckles the young; and among mammals the anatomical resemblances are closer and the differences less between man and certain apes than between man and the other mammals; so that zoölogists still, with Linnæus, include man with the monkeys and apes in one subdivision of the *Mammalia*, known as the *Primates*. That civilized man is mentally far superior to any other animal is no valid objection to such a classification, for zoölogical groups are defined by anatomical and not by physiological characters; and mental traits, since we know that their manifestation depends upon the structural integrity of certain organs, are especially phenomena of function and therefore not available for purposes of zoölogical arrangement.

As man walks erect with head upward, while the great majority of *Mammals* go on all fours with the head forward and the back

upward, and various apes adopt intermediate positions, confusion is apt to arise in considering corresponding parts in man and other animals unless a precise meaning be given to such terms as "anterior" and "posterior." Biologists, therefore, give those words definite arbitrary significations. The head end is always *anterior* whatever the natural position of the animal, and the opposite end *posterior*; the belly side is spoken of as *ventral*, and the opposite side as *dorsal*; *right* and *left* of course present no difficulty: the terms *cephalic* and *caudal* as equivalent, respectively, to anterior and posterior, are sometimes used. Moreover, that end of a limb nearer the trunk is spoken of as *proximal* with reference to the other or *distal* end. The words *upper* and *lower* may be conveniently used for the relative position of parts in the natural standing position of the animal.

The Vertebrate Plan of Structure. Neglecting such merely apparent differences as arise from the differences of normal posture above pointed out, we find that man's own zoölogical class, the *Mammals*, differs very widely in its broad structural plan from the groups including sea-anemones, insects or oysters, but agrees in many points with the groups of fishes, amphibians, reptiles and birds. These four are therefore placed with man and all other *Mammals* in one great division of the animal kingdom known as the *Vertebrata*. The main anatomical character of all vertebrate animals is the presence in the trunk of the body of two cavities, a dorsal and a ventral, separated by a solid partition; in the adults of nearly all vertebrate animals, a hard axis, the *vertebral column* (*backbone* or *spine*), develops in this partition and forms a central support for the rest of the Body (Fig. 2, *ee*). The dorsal cavity is continued through the neck, when there is one, into the head, and there widens out. Within it are inclosed the chief organs of the nervous system. The bony axis is also continued through the neck and extends into the head in a modified form. The ventral cavity, on the other hand, is confined to the trunk. It contains the main organs connected with the blood-flow together with those of digestion, respiration and excretion.

Upon the ventral side of the head is the *mouth-opening* leading into a tube, the *alimentary canal*, *f* (Fig. 2), which passes back through the neck and trunk and opens again on the outside at the posterior part of the latter. In its passage through the trunk-region this canal lies in the ventral cavity.

The Mammalia. In many vertebrate animals the ventral cavity is not subdivided, but in the Mammalia it is; a membranous transverse partition, the *diaphragm* (Fig. 1, *d*), separating it into an anterior *chest* or *thoracic cavity*, and a posterior, or *abdominal cavity*. The alimentary canal and whatever else passes from one of these cavities to the other must therefore perforate the diaphragm.

In the chest, besides part of the alimentary canal, lie important organs, the *heart*, *h*, and *lungs*, *lu* (Fig. 1); the heart being on the ventral side of the alimentary canal. The abdominal cavity is mainly occupied by the alimentary canal and organs connected with it and concerned in the digestion of food, as the *stomach*, *st*, the *liver*, *li*, the *pancreas*, and the small and large intestines, *si* and *c*.

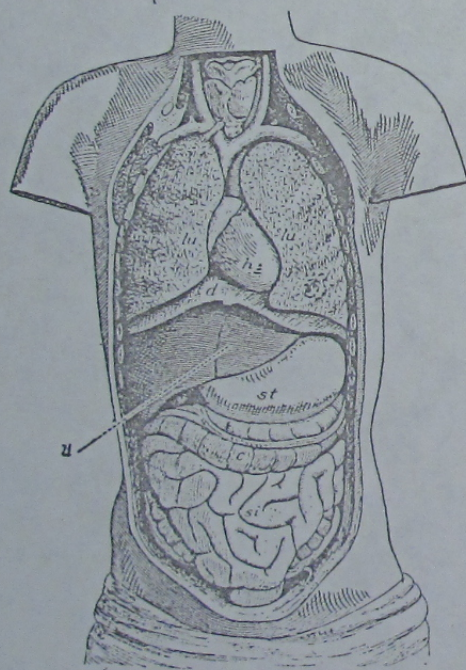


Fig. 1. — Diagram of the Body opened from the front to show the contents of the ventral cavity. *d*, diaphragm; *h*, heart; *lu*, lungs; *st*, stomach; *li*, liver; *si*, small intestines; *c*, large intestine.

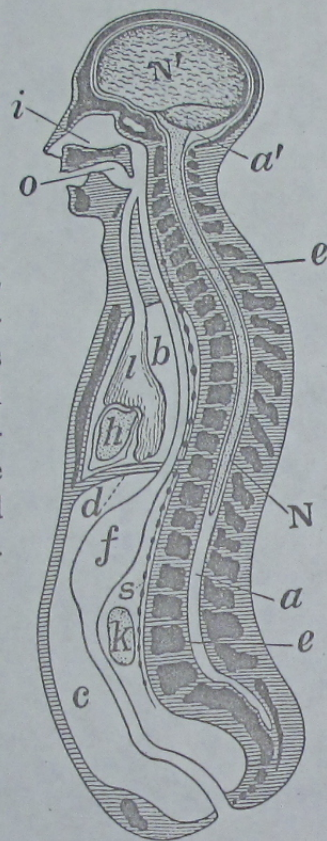


Fig. 2. — Diagrammatic longitudinal section of the Body. *a*, the neural tube, with its upper enlargement in the skull cavity at *a'*; *N*, the spinal cord; *N'*, the brain; *ee*, vertebræ forming the solid partition between the dorsal and ventral cavities; *b*, the pleural, and *c*, the abdominal division of the ventral cavity, separated from one another by the diaphragm, *d*; *i*, the nasal, and *o*, the mouth chamber, opening behind into the pharynx, from which one tube leads to the lungs, *l*, and another to the stomach, *f*; *h*, the heart; *k*, a kidney; *s*, the sympathetic nervous chain. From the stomach, *f*, the intestinal tube leads through the abdominal cavity to the posterior opening of the alimentary canal.

Among the other more prominent organs in it are the *kidneys* and the *spleen*.

In the dorsal or neural cavity lie the *brain* and *spinal cord*, the former occupying its anterior enlargement in the head. Brain and spinal cord together form the *cerebrospinal nervous center* commonly called the *central nervous system*; from this spring 43 pairs of nerve trunks, ramifying to all parts of the Body; these make up the *peripheral nervous system* (Fig. 53); in addition there are found in the ventral cavity a number of small nerve-centers united to each other and to the cerebrospinal center by connecting cords, and with their offshoots forming the *sympathetic nervous system*.

The walls of the three main cavities are lined by smooth, moist *serous membranes*. That lining the dorsal cavity is the *arachnoid*; that lining the chest the *pleura*; that lining the abdomen the *peritoneum*; the abdominal cavity is in consequence often called the *peritoneal cavity*. Externally the walls of these cavities are covered by the *skin*, which consists of two layers: an outer horny layer called the *epidermis*, which is constantly being shed on the surface and renewed from below; and a deeper layer, called the *dermis* and containing blood, which the epidermis does not. Between the skin and the lining serous membranes are *bones*, *muscles* (the lean of meat), and a great number of other structures which we shall have to consider hereafter. All cavities inside the Body, as the alimentary canal and the air-passages, which open directly or indirectly on the surface are lined by soft and moist prolongations of the skin known as *mucous membranes*. In these two layers are found as in the skin, but the superficial bloodless one is called *epithelium* and the deeper vascular one *corium*.

Diagrammatically we may represent the Human Body in longitudinal section as in Fig. 2, where *aa'* is the dorsal or *neural cavity*, and *b* and *c*, respectively, the thoracic and abdominal subdivisions of the ventral cavity; *d* represents the diaphragm separating them; *ee* is the vertebral column with its modified prolongation into the head beneath the anterior enlargement of the dorsal cavity; *f* is the alimentary canal opening in front through the nose, *i*, and mouth, *o*; *h* is the heart, *l* a lung, *s* the sympathetic nervous system, and *k* a kidney.

A transverse section through the chest is represented by the diagram Fig. 3, where *X* is the neural canal containing the spinal cord. In the thoracic cavity are seen the heart, the lungs, part of

the alimentary canal, *E*; bronchial tubes, *A*, leading to the lungs; and blood vessels, *B* and *PA*, communicating with the heart; the heavy line on each side covering the inside of the chest-wall and the outside of the lung represents the *pleura*.

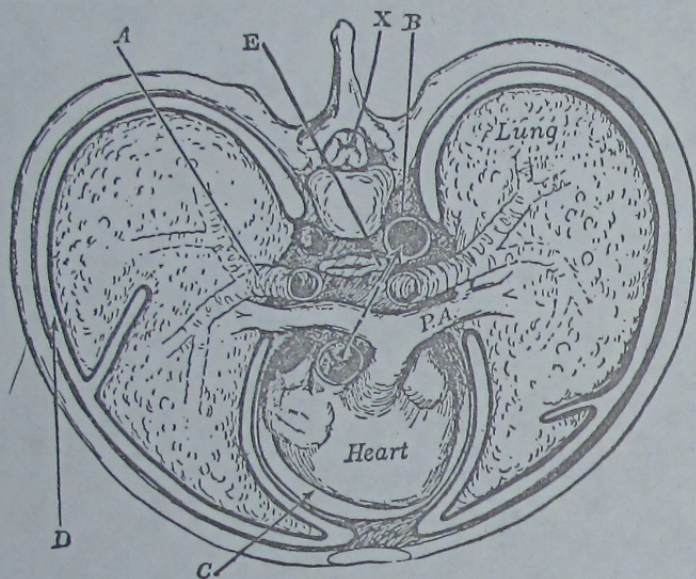


Fig. 3. — Cross-section of thorax. *A*, bronchus, entering the lung; *B*, the aorta cut at its origin and again at the descending part of its arch; *C*, the pericardial space; *D*, the pleural cavity; *E*, the alimentary canal; *PA*, the pulmonary artery; *X*, the neural canal.

Sections through corresponding parts of any other Mammal would agree in all essential points with those represented in Figs. 2 and 3.

The Limbs. The limbs present no such arrangement of cavities on each side of a bony axis as is seen in the trunk. They have an axis formed at different parts of one or more bones (as seen at *U* and *R* in Fig. 4, which represents a cross-section of the forearm near the elbow-joint), but around this are closely-packed soft parts, chiefly muscles, and the whole is enveloped in skin. The only cavities in the limbs are branching tubes which are filled with liquids during life, either *blood* or a watery-looking fluid known as *lymph*. These tubes, the *blood* and *lymph-vessels* respectively, are not, however, characteristic of the limbs, for they are present in abundance in the dorsal and ventral cavities and in their walls.

Microscopic Structure of the Body. For the detailed study of objects too small to be examined with the unaided eye the compound microscope is employed. Important optical conditions for

the successful use of this instrument are adequate illumination and sharpness of focus. To secure these in the study of tissues the materials are cut in very thin slices and observed by transmitted light. Viewed thus tissues in their natural state are so nearly transparent that relatively little of their detailed structure can be made out. The practice of histologists, therefore, is first to subject the tissues to the action of preservatives, and then to stain them with suitable dyes. By applying the principle that the different structures of the tissues are likely to differ *chemically* as well as in other respects, dyes can be selected which have greater affinity for some of the chemical components of the tissues than for others. Thus certain of the tissue components will stain with one sort of dye; other components are unaffected by this dye but can be stained with another. This method of *differential staining* enables the various features of tissues to be made clearly visible.

Cells. Examination of the different tissues with the aid of the microscope reveals that they are made up of minute structures, the *cells*. These vary in form and size in different tissues. They are all constructed on a common plan, although in the more highly organized tissues, such as nerves and muscles, this plan is so modified to meet the special demands of these tissues as not to be easily recognized. A typical unspecialized cell (Fig. 5) consists of a mass of living substance, known as *protoplasm*, of a semi-liquid, gelatinous consistency, about 0.01 millimeter ($\frac{1}{2500}$ inch) in diameter. The protoplasm is usually not perfectly uniform throughout, but shows granules or fine, transparent vesicles through its substance. Imbedded in the protoplasm is a small struc-

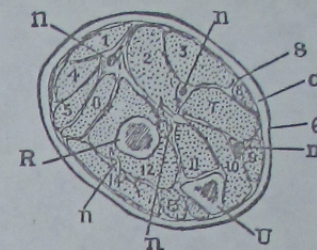


Fig. 4. — A section across the forearm a short distance below the elbow-joint. *R* and *U*, its two supporting bones, the radius and ulna; *e*, the epidermis, and *d*, the dermis of the skin; the latter is continuous below with bands of connective tissue, *s*, which penetrate between and invest the muscles, which are indicated by numbers; *n*, *n*, nerves and vessels.

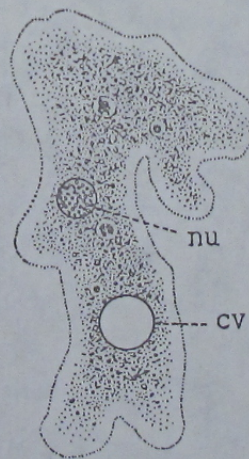


Fig. 5. — A simple one-celled organism (*Amoeba*) exemplifying an unspecialized cell; *nu*, nucleus; *cv*, contractile vacuole (this latter structure is absent from unspecialized cells of higher organisms).



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